Single-Cycle Versus Multicycle Proof Testing

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The overall objective of this effort is to assess the relative advantages and disadvantages of single-cycle versus multicycle proof testing and to understand and develop the optimum proof test logic.

Previous work done under this task has included an historical review of multicycle testing experiences and typical defects. The surface crack growth in Inconel 718 was experimentally characterized; a simple analytical model that used the reference stress estimates of *J* (elastic-plastic stress intensity) was developed; and resistance curves for surface cracks were developed to support the model that used a bounding approach for multicycle growth. Several critical experiments were performed, including studying the relationship between fatigue crack growth and ductile tearing, fractographic studies, acoustic emission monitoring, proper characterization of elastic-plastic fatigue crack growth, and conditions for identifying multicycle failure under load control. From the results of the above work, a second analytical model based on the tear-fatigue theory was developed.

Which is better: single-cycle or multicycle proof tests? The answer is not simple. The question must be asked in the right way. Looking at the question from a strictly deterministic view, for a single component that survives a proof test, multicycle proof testing will cause more crack growth than a single cycle. If the component survives, it will always be worse with multicycle proof testing. Looking at the question from a probabilistic basis, one must consider a population of components before versus after testing. Multicycle testing will cause more crack growth than single cycle, but it will remove more defective components from the population.

Service reliability is influenced by many factors, including material properties, service and proof loading, and component and crack geometry. Specific calculations of in-service reliability requires detailed fracture mechanics analysis coupled with probabilistic analysis. Specification of a single, simple, multicycle proof test protocol in every application is not feasible.

Other issues must also be considered when comparing single-cycle versus multicycle tests. Researchers must approach such other concerns as cracks at stress concentrators, hold-time effects, multicycle proof test failure due to damage coalescence, flaw shape changes, and weldment issues.

An engineering guidelines handbook for proof test design is being developed with emphasis on theory and validation of tear-fatigue algorithm for multicycle growth, as well as evaluation of single-cycle versus multicycle proof testing based on fleet reliability.

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